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RESEARCH ARTICLE

Heavy Metals in Wastewater Treatment Plants at Sharkia Governorate

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Abstract

The aim of the current study was to determine the presence of heavy metals (lead, cadmium, copper, and zinc) in three wastewater treatment plants at different locations in Sharkia Governorate, Egypt and its concentration compared with its natural level by following American Public Health Association strategies using atomic absorption spectrophotometer. Thirty wastewater samples were collected from wastewater before treatment (input) and treated wastewater (output) (15 samples of each) from Abo-Hammad, Diarb-Negm, and Al-Kenayat wastewater treatment plants. Total mean values of lead, cadmium, copper, and zinc in the input wastewater were 6.33±0.83, 1.09±0.12, 3.73±0.49 and 3.16±0.39 ppb, respectively while from output wastewater samples, respective values were 3.22±0.58, 0.49±0.09, 1.79±0.33, and 2.77±0.74 ppb. Lead and cadmium ions showed higher values above their natural level. Concerning copper, about 53.3% above its natural level while zinc concentration was within the natural level in all input and output samples. Diarb-Negm plant, which follows the Kroger technique, was the highest wastewater treatment plant in the removal of lead (57.1%), cadmium (75%) and copper (79.4%). While zinc removal percentage was highest (24%) in Abo-Hammad wastewater treatment plant which follows the trickling filter technique rather than other investigated plants. So the kroger technique is better than trickling filter technique in heavy metals removal.

Keywords: Heavy metals, Wastewater, Atomic absorption spectrophotometer, Trickling filter technique, Kroger technique.

Introduction

Water pollution is one of the most dangerous hazards affecting the majority of world countries. The change in water quality altering waters natural balance is known as water pollution. The pollution of water is linked to industry, sewage, or agricultural drainage, which supply the water bodies with large amounts of heavy metals. Thus, the contamination of heavy metals in water resources is a significant risk because of long persistence, toxicity, bioaccumulation, and bio magnification in the ecosystem and food chain [1].

Nowadays, the wastewater treatment plants were constructed in different regions in Egypt. These plants play an important role in the treatment of wastewater to be safe for agricultural purposes as well as for human and animal health. Therefore the investigation of such plants is more necessary for detecting its efficiency in the removal of dangerous pollutants such as heavy metals [2].

Given the human and animal health impacts, heavy metals can reach the human and animal body through ingestion of plants contaminated with heavy metal especially which irrigated by wastewater and from the contamination of surface water from natural and anthropogenic heavy metals sources of surface water in addition to consumption of fish polluted with concentrations of heavy metals. Each metal reveals different effects and symptoms according to exposure dose, duration of exposure, and the route of exposure [3]. Long-term, high-dose zinc supplementation leads to muscular stiffness,

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irritability, loss of appetite, nausea, vomiting, fatigue, epigastric pains and it interferes with the uptake of copper. Indigenous zinc influences apoptosis by acting on the cellular molecular regulators of programmed cell death, including caspases and proteins. While, zinc deficiency has a detrimental impact on growth, loss of appetite, neuronal development, slow healing of wounds, retarded growth of male sex organs, immunity, and depression [4]. On the other hand, copper (Cu) exposure in high concentrations generates serious toxicological concerns as it can be accumulated in the brain, liver, skin, myocardium, and pancreas. Chronic copper toxicity leads to hepatic cirrhosis, degeneration of basal ganglia, hemolytic anemia, thrombocytopenia, lymphopenia or neutropenia, hemolysis, and splenic sequestration while acute copper toxicity is known to cause leukocytosis. Wilson disease considers genetic conditions from severe copper toxicity [5-7]. The lead was considered as one of the most toxic heavy metals. It have latent long-term negative impacts on health, causing irreversible brain damage and encephalopathy, hepatitis, nephritic syndrome, replace the calcium in bones and affecting bone cells activities. In addition to, increasing the nonstandard secretion of amino acids, glucose and phosphates, inhibition of enzymes activity, injury of blood-forming systems, so anemia and crossing the placenta and damage fetal nervous system [8- 10]. Cadmium (Cd) exposure with high concentrations (intensive exposure) lead to the generation of cancer, mucous membrane destruction, kidney damage, bone damage, stomach pain, ulcer in stomach and small intestine, vomiting, diarrhea, pneumonia, reproductive failure, bone fracture infertility, and itai-itai disease, while at low concentrations it leads to flue like symptoms as fever, chills, and muscle ache [11,12].

The present study was designed to evaluate heavy metals concentration in three wastewater treatment plants at different locations in Sharkia Governorate. The heavy metals (Pb, Cd, Cu, and Zn) were determined in wastewater before treatment (input) and in treated wastewater (output) using atomic absorption spectrophotometer. Moreover, the removal percent of heavy metals in wastewater treatment plants was calculated.

Materials and Methods

In this study, 30 samples of wastewater were collected from three wastewater treatment plants (Abo-Hammad, Diarb-Negm and AL-Kenayat) at different locations in Sharkia Governorate. All wastewater samples were from public sewage mixed with industrial wastewater.

Topographical examination of investigated wastewater treatment plants

Abo-Hammad wastewater treatment plant is present in Abo-Hammad city with 20000 m^3/day capacity. It is about 11 acres and Belbes wastewater drain is the exit of treated water. It includes 4 treatment ponds.

Diarb-Negm wastewater treatment plant is located in Lebo village (about 7Km from Diarb-Negm city) with a capacity of 15000 m^3/day. The area of the plant is 5 acres with 8 treatment ponds. Equa wastewater drain is the exit of treated water.

Al-Kenayat wastewater treatment plant is located in Al-Kenayat city with a capacity of 20000m^3/day as in Abo-Hammad wastewater treatment plant. Area of plant is about 7 acres with 8 treatment ponds, while Equa wastewater treatment plant is the exit of treated water as mentioned in Diarb-Negm wastewater treatment plant.

Method of water treatment in wastewater treatment plants

Abo-Hammad and Al-Kenayat wastewater treatment plants follow the trickling filter technique, while Diarb-Negm wastewater treatment plant follows the Kroger technique.

A-Trickling filter technique:

This technique was done by several phases as the following:

1- Cooling room speed phase: as it works to reduce the speed of water before entering the next phase.
2- Mechanical strainers: remove large items such as paper and fabric, but it can’t remove sand.
3- Sand, oil, and grease basin: it is a basin with a slope to allow sand collection from the bottom of the basin to another basin, in addition to the removal of oil and grease

from the top surface of the basin to another basin.

4- Primary sedimentation basins (Primary sludge): it works on removal of 30-40% of organic loads, then gathered in a different muddy basin for concentrating and drying and converted to fertilizer to desert land only. The remaining water was collected to enter the next stage.

5- Gravel filters (biological treatment): contain two layers of gravel, each layer has a certain size, the first layer contains a gravel size of 4-8 cm and the other layer with 8-12 cm gravel. Each gravel contains a biofilm (microorganisms including protozoan as protozoa biocoenoses, metazoan as *Plectus aquatilis*, fungus and bacteria as *Comamonas denitrificans*, *Brachymonas denitrificans*, and *Aeromonas hydrophila*). on its surface which adsorb organic loads and release worm air which mixed with the cold air that inter through small holes in the wall of the basin producing dissolved oxygen that required for biofilm growth.

6- Final sedimentation basins: it works to calm and rest the water until the final remaining sludge is precipitated in the bottom of the basin, part of the sludge will be removed and converted to fertilizer for sand lands as mentioned previously while the other part returned to gravel filters for reactivation of biofilm.

7- Contact basins with chlorine: finally, the remaining water is come in contact with chlorine gas ($5cm^3/L$) for more purification before getting out from wastewater treatment plants.

B-Kroger technique:

The same steps are applied except the gravel filters phase that is replaced with the extended ventilation system where the vacuum is stirred with oxygen in the wastewater by a tube with a three-quarter in the water and another quarter in the air for good ventilation.

Collection of samples

A total of thirty water samples were collected from examined wastewater treatment plants on weekly bases for five weeks beginning from November 2017. Half of the samples) 15 samples) were from the input of plants before treatment and the other samples were from the output after treatment (10 samples from each plant, 5 from input and 5 from the output).

The technique of water sampling from the input of wastewater treatment plants was carried out according to the recommendation of American Public Health Association (A.P.H.A) [13]. By using a sterilized bottle which prewashed with 1 (N) HNO_3 and deionized water and caged with a load having two cords one attaching to the neck and the other attaching to the stopper. The sterilized bottle was lowered closed to a suitable depth and filled by jerking movement of the stopper using the attached cord. Then the bottle was raised to the surface and restoppered. While samples from output were collected from tap connected to the tank then the treated wastewater was allowed to run for at least five minutes before collecting the samples. Each sample was identified by labeling it showing its source, date, and site of sampling. Finally, 5mL of 1:1 HNO_3 was added to each collected water sample.

All collected samples were transferred to the laboratory of the Veterinary Public Health Department, Faculty of veterinary Medicine, Zagazig University with a minimum of delay (not more than 2 h). Delayed samples were stored in an ice bag during transportation to the laboratory and preserved at 4°C, before analysis, and then the sample was filtered by 0.45 µm Whatman membrane filter paper. Lead (Pb), cadmium (Cd), copper (Cu), and zinc (Zn) concentrations in the collected samples were analyzed using the atomic absorption spectrophotometer (AAS)(T80 PG instruments ltd UV / VIS. Spectrophotometer, U.K) in the Central lab of Faculty of Veterinary Medicine, Zagazig University. The analytical findings were articulated in terms of µg/L (ppb).

Statistical analysis

Results were analyzed by SPSS version 25 (Armonk, NY: IBM Corp). Data reported as mean ± SE. The student's t-test was applied to test differences in heavy metal removal (Lead, Cadmium, Cupper, and Zinc) between input (before wastewater treatment) and output (after wastewater treatment). $P < 0.05$ was considered statistically significant.

Results and Discussion

As demonstrated in Table 1 the total mean lead value in the input wastewater (before treatment) was found to be 6.33±0.83ppb. A lower finding (0.04-0.37ppb) was reported in India [14]. After treatment, total mean lead concentration in the output of wastewater treatment plants was 3.22±0.58 ppb. A higher finding was previously reported in Brazil where lead concentration in the output of treated wastewater was 22.75ppb [15].

Table 1: Lead concentration (μg/L) in examined wastewater samples in different wastewater treatment plants

Wastewater treatment Plants	Treatment method	§Input wastewater	§Output treated water	Removal %	*P*-value
Abo-Hammad	trickling filter	3.8 ± 0.62	2.44 ± 0.70	36.8	0.03*
Diarb-Negm	kroger	9.1 ± 1.43	3.9 ± 1.44	57.1	0.02*
Al-Kenayat	trickling filter	6.3 ± 1.1	3.3 ± 0.80	47.6	0.06
Total mean	__	6.33 ± 0.83	3.22 ± 0.58	47.17	---

Values are mean ± SE. §No. of input samples = 15 (5 samples for each plants) and No. of output samples = 15 (5 samples for each plants). * Denotes significant difference ($P < 0.05$).

It was noticeable that removal percent of lead was in the following order Diarb-Negm > Al-Kenayat > Abo-Hammad as 57.1 > 47.6 > 36.8%, where the highest removal percentage was observed in Diarb-Negm, while the lowest was in Abo-Hammad, so the total removal percentage of lead was 47.17%. A similar lead removal percentage (39.7%) was reported in Brazil in a wastewater treatment plant [15].

This variation in lead concentration among the three wastewater treatment plants may be attributed to the difference in levels of contamination source in Diarb-Negm and Al-Kenayat city more than in Abo-Hammad city as batteries and ceramic manufactories which present in Abo-Hammad and Diarb-Negm cities in addition to painting, plastic and wood preservative factories that present in Al-Kenayat city. These results substantiated what has been previously reported by Lassen and Hansen [16] who found sources of lead as 48% produced from batteries, 0.5% from ceramic and 0.1% produced from gasoline in Denmark. However, in Stockholm, Lohm et al. [17] reported that lead released in 42% from power cable manufacture, 15% from batteries, and 1% from the manufacturing of wood preservatives. Moreover, lead released from the manufacturing of batteries, printing, fuels, explosives and photographic materials [18].

From the hygienic point of view, lead target organs are the reproductive, renal, hematopoietic, and central nervous system. Its toxicity leads to poor attention span, dullness, irritability, memory loss, muscular tremor and headache, proximal tubular nephropathy, glomerular sclerosis, interstitial fibrosis, proteinuria, impaired transport of organic anions and glucose, and depressed glomerular filtration rate [19].

There was a significant reduction in lead removal after wastewater treatment in Abo-Hammad and Diarb-Negm ($P < 0.05$), while the reduction in the lead after treatment was not statistically significant in Al-Kenayat ($P > 0.05$).

As seen in Table 2, the examination of input water of wastewater treatment plants clarified that the total mean cadmium value was 1.09±0.12 ppb in wastewater treatment plants (WWTPs). Lower findings were previously reported by Mushtaq and Khan [20] who detected cadmium concentration as 0.03; 0.02 and 0.02 ppb in the wastewater of Andiala, Pirwadhai and Taxilla in Pakistan. While in Poland wastewater cadmium concentration (0.02 ppm) was higher than that obtained in current study [21]. On the other hand, the total mean cadmium concentration in output wastewater treatment plants was 0.49 ± 0.09 ppb in Abo-Hammad, Diarb-Negm, and Al-Kenayat wastewater treatment plants, respectively. Cadmium concentration in output wastewater of Canada was 0.001ppm [22].

It was found that the total mean removal percentage was 47.17% as 75; 63.6 and 20% in

Diarb-Negm, Al-Kenayat, and Abo-Hammad wastewater treatment plants respectively. Diarb-Negm wastewater treatment plant was the highest one in cadmium removal percentage (Table 2).

The presence of cadmium with different concentrations in wastewater treatment plants is due to several industrial processes such as pigments, batteries, electroplating, and paints manufacturing which release cadmium ions in their drainage in water [23, 24].

From the hygienic aspect of view, cadmium target organs are kidney, liver, bones, and lung so its short-term exposure symptoms as nausea, vomiting, abdominal cramps, dyspnea and muscular weakness. However, long-term exposure lead to renal dysfunction, obstructive lung disease, pneumonitis, emphysema, bronchiolitis and alveolitis, pulmonary edema, chest pain, cough with foamy and bloody sputum, in addition to bone defects, such as osteomalacia, spontaneous and fractures osteoporosis. Also, it induces increased blood pressure and myocardial dysfunctions [25].

There was a significant reduction in cadmium removal after wastewater treatment in Abo-Hammad (P < 0.05), and a highly significant in Diarb-Negm (P < 0.01), while the reduction in cadmium after treatment was not statistically significant in Al-Kenayat (P > 0.05).

Concerning copper, it was clear from Table 3 that the total mean value of copper in samples taken from the input of wastewater was 3.73±0.49 ppb in wastewater treatment plants. In Isfahan, Iran, copper concentration in wastewater was 0.023 ppm [26]. In India, a lower finding was detected in a range from 0.02 to 0.13 ppb [22]. Moreover, the total mean value of copper in samples taken from output was 1.79 ± 0.33 ppb. A higher finding was previously reported in Brazil where copper concentration was 9.66 ppb in the output of treated wastewater [15].

Table 2: Cadmium concentration (µg/L) in examined wastewater samples in different wastewater treatment plants

Wastewater treatment Plants	Treatment method	§Input wastewater	§Output treated water	Removal %	*P*-value
Abo-Hammad	trickling filter	1 ± 0.17	0.8 ± 0.17	20	0.024*
Diarb-Negm	kroger	1.16 ± 0.29	0.32 ± 0.16	75	0.004**
Al-Kenayat	trickling filter	1.1 ± 0.22	0.4 ± 0.09	63.6	0.064
Total mean	__	1.09 ± 0.12	0.49 ± 0.09	52.87	-----

Values are mean ± SE. §No. of input samples = 15 (5 samples for each plants) and No. of output samples = 15 (5 samples for each plants). * Denotes significant difference (P < 0.05) and ** Denotes highly significant difference (P <0.01).

Table 3: Copper concentration (µg/L) in examined wastewater samples in different wastewater treatment plants

Wastewater treatment plant	Treatment method	§Input wastewater	§Output treated water	Removal %	*P*-value
Abo-Hammad	trickling filter	4.1 ± 1.12	2.4 ± 0.72	41.5	0.03*
Diarb-Negm	kroger	3.4 ± 0.92	0.72 ± 0.29	79.4	0.02*
Al-Kenayat	trickling filter	3.7 ± 0.58	2.3 ± 0.36	37.8	0.06
Total mean	__	3.73 ± 0.49	1.79 ± 0.33	52.9	---

Values are mean ± SE. §No. of input samples = 15 (5 samples for each plants) and No. of output samples = 15 (5 samples for each plants). * Denotes significant difference (P < 0.05).

The total removal percentage of copper was 52.9%, in the Diarb-Negm wastewater treatment plant, about 79.4% of copper ions were removed, while about 41.5 and 37.8% were also removed in Abo-Hammad and Al-Kenayat wastewater treatment plants. In Brazil, only about 44.2% of copper ions were removed in wastewater treatment plant [15]. Increasing copper concentration in samples that were taken from wastewater treatment plants of Abo-Hammad and Al-Kenayat cities may be attributed to industrial pollution. Copper reaches water through industrial effluents such as metal cleaning, plating baths, and ceramic manufacturing [27].

Public health significance of copper indicated that its acute toxicity can result in several pathologies such as vomiting, nausea, diarrhea, abdominal pain, coronary heart diseases and high blood pressure and in severe cases, death. However, chronic cupper toxicity can result in liver disease and severe neurological defects as Alzheimer's disease and Wilson disease [28].

On the other hand, copper removal after wastewater treatment revealed a significant reduction in Abo-Hammad and Diarb-Negm ($P < 0.05$). Moreover, the reduction in Al-Kenayat after wastewater treatment was not statistically significant ($P > 0.05$).

Regarding zinc in wastewater treatment plants, Table 4 showed that the total mean zinc value was 3.16±0.39 ppb in samples taken from the input, while the total mean output concentration was 2.77±0.74 ppb. On the other hand, the maximum removal percentage of zinc was 24% in Abo-Hammad wastewater treatment plant followed by 18.4 and 0% in Diarb-Negm and Al-Kenayat wastewater treatment plants, respectively. This finding indicated that zinc total mean removal percentage value was 14.13%. In Ataqa region, Egypt, zinc concentration in the input and output water of wastewater treatment plant was 0.038 ± 0.038 and 0.008 ± 0.007 ppm with 59.6% removal percentage [29]. However, in a previous study in Egypt, zinc concentration recorded in samples taken from input and output wastewater treatment plants was 1.179 and 1.129 ppm [30]. A lower finding was previously reported by Mushtaq and Khan [20] who found that zinc concentration in samples taken from input of wastewater in Andiala, Pirwadhai, and Taxilla was 0.01-0.35; 0.00-0.17 and 0.00-0.02 ppb, respectively.

Zinc is mostly introduced into water by artificial pathways such as by-products of steel production or from the burning of waste materials. In addition, older galvanized metal pipes are coated with zinc that may be dissolved by soft, acidic water particles that present in wastewater and sea salts leading to an increase in its concentration in wastewater [31].

From the public health significance, symptoms from excessive zinc exposure have been recognized by vomiting, nausea, and fatigue with epigastric pain. Also, it interferes with copper uptake and affecting cell activity leading to cell death [32]. The reduction of zinc in all the examined wastewater treatment plants was not statistically significant ($P > 0.05$).

Finally, it is noticed that the Diarb-Negm wastewater treatment plant was the best one in removing lead, cadmium, and copper ions. This may be due to the method of water treatment (Kroger trichinae) that is based on the extended ventilation system (Tables 1-3).

On the other hand, it was noticeable that mean concentrations of measured heavy metals in all wastewater treatment plants were comparatively higher in the input water samples (before treatment) more than in output water samples (after treatment). This may ensure the role of numerous stages during the treatment of wastewater in the reduction of heavy metals level. These results were agreed with those reported before Lasheen *et al*. [33] who noticed a reduction of cadmium, lead, and copper concentration in samples collected from the output of water treatment plants in Cairo, Egypt.

Table 4: Zinc concentration (μg/L) in examined wastewater samples in different wastewater treatment plants

Wastewater treatment plants	Treatment method	*Input wastewater	*Output treated water	Removal %	*P*-value
Abo-Hammad	trickling filter	2.5 ± 0.62	1.96 ± 0.53	24	0.08
Diarb-Negm	krogger	3.82 ± 0.90	3.1 ± 1.3	18.4	0.33
Al-Kenayat	trickling filter	3.2 ± 0.37	3.24 ± 1.43	0	0.98
Total mean	___	3.16 ± 0.39	2.77 ± 0.74	14.13	---

Values are mean ± SE. *No. of input samples = 15 (5 samples for each plants) and No. of output samples = 15 (5 samples for each plants).

Table 5: Frequency distribution of heavy metals in wastewater samples from different wastewater treatment plants

Heavy metals	Input wastewater				Output treated wastewater			
	Within natural level		Over natural level		Within natural level		Over natural level	
	No. of samples	%	No. of samples	%	No. of samples	%	No. of samples	%
Lead	0	0	15	100	0	0	15	100
Cadmium	0	0	15	100	1	6.7	14	93.3
Copper	2	13.3	13	86.7	7	46.7	8	53.3
Zinc	15	100	0	0	15	100	0	0

N.B: Natural level of lead, cadmium, copper, and zinc were 0.2, 0.07, 1.8 and 10 μg/L, respectively (Forstner and Wittmann, 1979).

From the result depicted in Table 5, it was noticed that both lead and cadmium in the wastewater samples taken from input source were above the natural levels (0.2 and 0.07 μg/L) that was recorded by Forstner and Wittmann [34] in all investigated treatment plants (100%). However, in the case of copper, about 86.7% of samples were above the natural level (1.8 μg/L). On the other hand, in samples taken from output water, lead concentration was above its natural level (0.2 μg/L) by 100%. Concerning cadmium, only one sample was within natural level (6.7%) and other samples (93.9%) were above the natural level (0.07 μg/L). Regarding copper, 53.3% of examined output water samples were above natural level (1.8 μg/L). On the other aspect, zinc concentration in all examined samples (input and output) was within zinc natural levels (10 μg/L).

Conclusion

It can be concluded that the wastewater treatment plants had higher lead, cadmium, copper, and zinc concentrations in water taken from input than in output. Abo-Hammad and Al-Kenayat wastewater treatment plants follow the trickling filter technique, which was done by several phases. In the Diarb-Negm wastewater treatment plant, the Kroger technique was used. Lead and cadmium ions showed higher values above their natural levels. The best system for removal of zinc was recorded in Abo-Hammad which used the trickling filter technique; however Diarb-Negm was the best one in the removal of lead, cadmium, and copper ions, which used Kroger technique.

Conflict of interest

No one of the authors have any conflict of interest to declare.

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الملـخـص العربى

المعادن الثقيلة في محطات معالجة مياه الصرف الصحي بمحافظة الشرقية

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الهدف من الدراسة الحالية هو تحديد وجود المعادن الثقيلة (الرصاص ، والكادميوم ، والنحاس ، والزنك) في ثلاث محطات معالجة مياه الصرف الصحي في مواقع مختلفة بمحافظة الشرقية بمصر وتركيزها مقارنة بمستواها الطبيعي باتباع جمعية الصحة العامة الأمريكية. استراتيجيات باستخدام مقياس الامتصاص الذري. تم تجميع ثلاثين عينة من مياه الصرف الصحي قبل المعالجة (المدخلات) ومياه الصرف الصحي بعد المعالجة (المخرجات) (15 عينة لكل منها) من محطات معالجة مياه الصرف الصحي في أبو حماد وديرب نجم والقنايات. كانت القيم المتوسطة الإجمالية للرصاص والكادميوم والنحاس والزنك في مياه الصرف الصحي المدخلات 6.33 ± 0.83 ، 1.09 ± 0.12 ، 3.73 ± 0.49 و 3.16 ± 0.39 جزء في البليون ، على التوالي بينما من عينات مياه الصرف الصحي الناتجة ، كانت القيم المعنية 3.22 ± 0.58 ، 0.49 ± 0.09 و 1.79 ± 0.33 و 2.77 ± 0.74 جزء في البليون. أظهرت أيونات الرصاص والكادميوم قيم أعلى من مستواها الطبيعي. فيما يتعلق بالنحاس، زاد بنسبة 53.3٪ عن مستواه الطبيعي، بينما كان تركيز الزنك ضمن المستوى الطبيعي في جميع عينات المدخلات والمخرجات. كان معمل ديرب نجم الذي يتبع تقنية كروجر أعلى محطة لمعالجة المياه العادمة في إزالة الرصاص (57.1٪) والكادميوم (75٪) والنحاس (79.4٪). بينما كانت نسبة إزالة الزنك هي الأعلى (24٪) في محطة معالجة مياه الصرف الصحي بأبو حماد التي تتبع تقنية الترشيح المتقطر وبالتالي تقنية كروجر أفضل من تقنية الترشيح المقطر في إزالة المعادن الثقيلة.